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November 24, 2015

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Indianapolis, IN 46204-2251

RE: SCR Pilot Study Design Report/ Logansport Kiln 2

To whom it may concern:

Enclosed please find a copy of Essroc's Design Report for the SCR Pilot Study to be conducted on Logansport Kiln 2. We respectfully ask that your agency provide prompt approval of the design report. The First Modification to the Consent Decree provides that Essroc shall obtain EPA and IDEM approval prior to commencing the pilot study.

Please telephone if you should have any questions regarding the report.

Thank you.

Anthony Jones
Director Environment

Cc: Philip J. Schworer, Esq.

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ESSROC CEMENT CORP

DESIGN REPORT

SCR PILOT STUDY

LOGANSPOORT KILN 2

I. Introduction

The First Modification to the Consent Decree between Essroc Cement Corp (“Essroc”), U.S. EPA and the Affected States provides that Essroc shall submit a Design Report for review and approval prior to conducting the Second SCR Pilot Study. The Design Report shall be submitted to EPA on or before November 30, 2015.

II. Requirements for the Design Report

The First Modification to the Consent Decree provides that the Second SCR Pilot Study have the following design elements:

1. The system will be designed to reduce NOx emissions by at least 80%.
2. The system may also be designed to employ features shown to be successful in other industries, such as a sacrificial catalyst layer to address poisons, on-line soot blowing to address pluggage and deactivation, and temperature monitors, as well as other features deemed appropriate by the system designer to ensure successful operation of the SCR
3. The design report will include a plan to measure any dioxin/furan in the test gas stream.
4. The system will be designed to use a gas reheat system to achieve a temperature high enough to prevent ammonium bisulphate fouling of the catalyst.
5. Essroc will not implement the proposed plan until the EPA has approved the proposed plan.
6. The study will collect at least 120 operating days of valid data.
7. The results of the Second SCR Pilot Study Report will be evaluated based upon the parameters listed in paragraph 5 of Appendix B of the 2012 Decree.
 - a. Emission reductions of NOx
 - b. Observed deactivation or poisoning of catalyst in the SCR
 - c. Ammonia usage
 - d. Adverse environmental consequences related to the use of the SCR
 - e. Anticipated and observed lifetime of the catalyst
 - f. Anticipated or observed space velocity of the system

8. After approval of the results from the Second SCR Pilot Study and subject to Essroc's claim of Confidential Business Information under 40 C.F.R. Part 2, Essroc and its consultant will produce a comprehensive technical report for the Second SCR Pilot Study.
9. The technical report will be posted on Essroc's website and in written form and/or verbally at conferences as appropriate.
10. EPA, in its discretion, may publish the technical report on its website.

III. Design Report

The above-listed design elements for the Second SCR Pilot Study are addressed in the attached proposal prepared by Fossil Energy Research, Corp ("FERCO").

IV. Approval Implementation

Essroc will implement the Design Report, following EPA's approval by engaging FERCO to perform the work.

Essroc will hire a qualified emissions testing company to perform EPA Method 23 tests to determine the dioxin/furan emissions. Isokinetic samples of the stack gas will be extracted from a single point in the nominal 4-inch inlet and outlet ductwork.

SCR PILOT STUDY

Prepared for

Essroc Italcementi Group
Nazareth, Pennsylvania

Prepared by

Fossil Energy Research Corporation
Laguna Hills, California

November 2015



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1

INTRODUCTION

The purpose of this project is to conduct a pilot study of Selective Catalytic Reduction (SCR) for NO_x control on Kiln #2 at the Essroc Cement Corp. (Essroc) facility in Logansport, IN. The pilot study is a required part of the First Modification to the Consent Decree between Essroc, U.S. EPA, and the affected states. The scope of the study includes the design of a pilot SCR system, as well as the specification of a test program which will provide 120 days of valid operating data. Fossil Energy Research Corp. (FERCo) and Essroc will describe these two tasks in a "Design Report" (this document), which will then be submitted to and reviewed by U.S. EPA. Once reviewed and approved, FERCo will use the Design Report as the basis for the detailed design of the pilot SCR system. FERCo will then fabricate and install the pilot SCR system at the Logansport facility, and operate it through the 120-day test program.

An external slipstream SCR reactor system will be utilized for the proposed study. The primary design criteria for the system are as follows:

- The system will be designed to provide a reduction in NO_x emissions of 80%.
- The system will be designed to provide a pressure drop across the catalyst of less than 2 inches of water.
- The system will utilize a flue gas reheat system to provide temperatures high enough to prevent ammonium bisulfate (ABS) fouling of the catalyst.
- The system will be designed to operate nearly autonomously on a 24x7 basis to achieve the 120 days of valid data.
- The system will utilize a catalyst type typically used in systems where flue gas contains particulate.

The detailed slipstream reactor design elements and the choice for SCR catalyst material will be based on FERCo's extensive experience in designing, building and operating pilot-scale SCR systems applied to coal-, oil- and gas fired utility boilers for various clients over the past 30 years (see Appendix A). The following sections will provide more detail on the design of the pilot system.

2

SLIPSTREAM REACTOR LOCATION AND DESIGN

SCR reactors for coal-fired utility boilers are usually positioned in the “dirty” gas stream ahead of the particulate control device in order to avoid having to reheat the flue gas to the optimum catalyst temperature range of 600°F to 700°F. Particulate (fly ash) deposition on the catalyst in these systems can generally be managed with the use of cleaning devices such as sootblowers and acoustic horns. However, research performed by FERCo (conversations with the SCR catalyst engineers at Haldor-Topsoe) indicates that in the cement industry the particulate loading ahead of the particulate control device is significantly higher than in a coal-fired utility application, so the SCR reactors are placed downstream of the primary particulate control device.

Logansport Kiln 2 has an electrostatic precipitator (ESP) for particulate control, and the pilot SCR slipstream will be taken from the “clean” flue gas stream downstream of the ESP. Data provided by Essroc indicates the gas temperature in this region is nominally 240°F. SCR performance is highly temperature dependent, so the flue gas will need to be reheated to a higher temperature in order to provide efficient NO_x removal. At a minimum, the flue gas will have to be reheated to a temperature above the ammonium bisulfate (ABS) formation temperature. Data provided by Essroc indicate NO_x concentration at the exit of the Kiln 2 ESP is nominally 300 ppm, and the SO₃ concentration is approximately 0.13 ppm. Operating the pilot SCR at a NO_x removal level of 80% will require an ammonia injection rate of roughly 240 ppm. With this NH₃ level, and assuming SO₃ levels ranging from 0.13 to 0.50 ppm, the calculated bulk ABS formation temperature ranges from 445°F to 470°F. The ABS formation temperature for capillary condensation (calculated based on the minimum pore size for the catalyst material chosen) ranges from 490°F to 520°F. Thus, in order to avoid ABS formation and fouling of the SCR catalyst material, the flue gas must be reheated to at least 520°F.

However, there is also concern regarding dioxin/furan formation across the SCR catalyst at elevated temperatures. A quick literature search indicates SCR operating temperatures below nominally 480°F result in minimal dioxin/furan formation. However, this temperature is well below the ABS formation temperature calculated above. Thus in order to keep the dioxin/furan formation as low as possible, while still providing a safe margin above the ABS formation temperature, the flue gas will be reheated to only 525°F. An electric immersion-type heater will be used to provide the flue gas reheat. The heater will be sized to provide a temperature increase of nominally 400°F (approximately 30% excess capacity).

The size of the catalyst sample utilized for the SCR pilot will be based on the standard “test coupon” dimensions found throughout the coal-fired utility industry of 150 mm by 150 mm (nominally 6 inch by 6 inch) in cross-section. The length of the catalyst sample will be a minimum of 1 meter, which corresponds to the nominal depth of a catalyst layer in a coal-fired utility application. However, the length of the catalyst sample may be adjusted to a length

longer than 1 meter, in order to assure 80% NO_x removal at the less than optimal operating temperature of 525°F. FERCo set the final overall length of the catalyst sample after discussing the NO_x removal requirements and temperature limitations with the catalyst vendor.

The catalyst will be of a type typically used with flue gas containing particulates. In the utility industry, the coal-fired SCR systems in most cases process all of the fly ash through the catalyst matrix. Catalysts used for this application include plate catalyst, extruded honeycomb catalysts, and corrugated catalysts (similar in geometry to extruded honeycomb catalyst). It should be noted that for applications where the catalyst is located downstream of a particulate control device (i.e., ESP or fabric filter) catalyst plugging can still be an issue. Downstream of these devices there is still a small quantity of very small diameter particulates. It turns out that these small particulates can be very tenacious in plugging SCR catalyst. This has been experienced with utility "Hot Side" ESP units where the ESP and SCR are located ahead of the Air Preheater. Catalyst plugging has been an issue in these units and a catalyst with a larger channel opening is being retrofit in these SCR reactors. Biomass SCR units typically have the SCR located downstream of either an ESP or multiclone. These units have also experienced plugging by fine ash particles. This fine particle plugging mechanism needs to be a major consideration in selecting the catalyst for this pilot plant study.

In preparing this proposal, two other catalyst issues were raised. First, is a packed bed catalyst geometry appropriate for this application? The answer is no, based on the catalyst plugging discussion above. Plugging of a packed bed catalyst would be markedly more severe than the catalyst types discussed above.

Second, should a sacrificial catalyst layer be considered? A sacrificial layer may be appropriate to limit catalyst poisoning. For instance with some high sulfur Eastern coals the main catalyst poisoning mechanism is due to arsenic. In these units, the first layer of catalyst can lose half its activity in a couple of months with markedly less deactivation of the layers below. To make a decision on the use of a sacrificial layer requires that the poisoning mechanism be known. This is not the case for this application. In fact, one of the outputs from this proposed study will be an indication of what the poisoning mechanisms are, if any.

Common free-stream approach velocities ahead of the catalyst for coal-fired utility applications range from 15 ft/sec to 18 ft/sec (actual). For a gas temperature of 525°F and a nominal 6-inch by 6-inch catalyst cross-section, this velocity range yields a flue gas flow range of 119 scfm to 143 scfm. Therefore, the target reactor design flow rate will be set at 130 scfm.

The motive power for the slipstream reactor system will be provided by a hot gas fan located upstream of the flue gas reheat section in the area where the gas temperature is nominally 240°F. The blower will be controlled by a variable frequency drive (VFD) and flue gas flow rate will be measured by a venturi flow meter located downstream of the SCR catalyst reactor. A feedback control loop will utilize the measured venturi flow rate to control the VFD/fan combination to automatically maintain the flue gas flow at the desired setpoint value.

A slipstream of flue gas will be pulled from the Logansport Kiln 2 exhaust duct downstream of the ESP. The gas will pass through the hot gas fan, and then through the reheat section. Ammonia will be injected and then the flue gas passes through a static mixer section to assure the ammonia is thoroughly mixed into the gas stream. The flue gas will then flow through the SCR catalyst reactor section, through the venturi meter, and will then be returned to the Kiln 2 ESP outlet duct.

The ductwork and SCR catalyst reactor sections will be constructed from 304 stainless steel. The ductwork ahead of the reheat section will be nominal 3-inch to 4-inch diameter tube, depending on the hot gas fan connections. The size and configuration of the reheat section will be determined during the detailed system design to follow U.S. EPA approval of this design report. The duct work from the reheat section to the SCR catalyst reactor inlet will be 4-inch diameter tube, and will transition to a nominal 6-inch by 6-inch square cross-section. The inside dimensions of the catalyst reactor will be approximately 6.125 inches by 6.125 inches to accommodate a "standard" 150 mm by 150 mm catalyst sample and holder assembly. Downstream of the catalyst the ductwork will transition from a nominal 6-inch by 6-inch square cross-section down to a 4-inch diameter tube. The venturi meter inlet and outlet sections will be 4-inch diameter tube as will the flue gas return to the Kiln 2 ESP outlet duct.

All sections of the slipstream reactor flow path will be encased in electrically heated jackets to maintain the desired flue gas temperature. The ductwork ahead of the reheat section will be heated to maintain the temperature of the flue gas pulled from the Kiln 2 ESP outlet duct (approximately 240°F). The ductwork downstream of the reheat section, including the SCR reactor and venturi meter, will be heated to maintain the catalyst setpoint temperature of 525°F. Provision will also be included to preheat the system during a kiln and pilot plant start up.

The nominal 1-meter long SCR catalyst reactor will be separated into two 0.5-meter sequential sections with a small open space between the two sections. This is similar to how both plate- and corrugated-type SCR catalyst modules are configured for coal-fired utility boiler applications. FERCo's experience with full-scale SCR systems installed downstream of the primary particulate control device, has shown there have been many issues with very fine particulate depositing on the catalyst surface in these systems. For this reason, a manually operated rake-style sootblower (utilizing compressed air at the sootblowing medium) will be installed at the inlet of the catalyst reactor, as well as within the open space at the inlet of the second nominal 0.5-meter long catalyst section. Both these sootblowers will require manual operation by on-site Essroc personnel on a daily basis throughout the test program.

In addition to the sootblowing measures outlined above, the catalyst itself will be selected with a layer pitch designed to accommodate the possibility of very fine particulate in the flue gas stream. FERCo suggests utilizing Haldor-Topsoe (H-T) corrugated catalyst in the pilot SCR system. H-T is a major catalyst supplier for coal-, oil-, and gas fired utility SCR applications. Additionally, Haldor-Topsoe has experience with the application of SCR to both hazardous waste incinerator and cement kiln applications. Finally, H-T has experience with SCR systems installed downstream of the primary particulate control device.

The source of ammonia for the pilot SCR system will be compressed gas cylinders of anhydrous ammonia. The ammonia injection rate will be maintained by a mass flow controller (MFC). For day-to-day operations, the ammonia injection rate will be set to maintain a NO_x removal level of 80%. Data provided by Essroc indicates the NO_x concentration downstream of the Logansport Kiln 2 ESP is nominally 300 ppm. Preliminary calculations of the ammonia injection rate required for 80% removal and an inlet NO_x level of 300 ppm indicate an ammonia consumption rate of approximately 2 lbs/day. A 120-day test will require two 150 lb (net) cylinders of anhydrous ammonia.

3

INSTRUMENTATION AND MEASUREMENTS

3.1 Process Instrumentation

The pilot SCR system will be fully instrumented to allow sufficient control and monitoring of all significant system operating parameters. All instrumentation outputs will be recorded and logged by a PLC/DAQ system designed by FERCo. This system will record 5-minute averages for all data points on a 24x7 basis. In particular, the flue gas temperature at the following points will be measured with type-K thermocouples and recorded:

- The gas temperature inside the Kiln 2 ESP outlet duct
- Hot gas fan inlet
- Reheat section inlet and outlet
- At the static mixer downstream of ammonia injection
- Catalyst reactor inlet (grid of three thermocouples across the 6-inch by 6-inch diagonal)
- Catalyst reactor outlet (grid of three thermocouples across the 6-inch by 6-inch diagonal)
- Venturi meter outlet

Additionally, the heated jacket surface temperatures for each individual heater will be recorded. The following flow-related data will also be measured and recorded:

- Pressure drop across the nominal 1-meter long catalyst bed
- Pressure drop across the venturi meter
- The calculated slipstream gas flow (based on the venturi meter pressure drop and temperature)
- VFD output (Hz) to the hot gas fan
- Ammonia injection rate from the MFC

The PLC/DAQ system will provide overall operating control of the slipstream system. This functionality will include two PID control loops. The first will maintain the flue gas flow at the setpoint value by monitoring the flow through the venturi meter and adjusting the VFD output to the hot gas fan. The second PID loop will maintain a NO_x removal setpoint by monitoring the NO_x removal measured across the SCR catalyst reactor and adjusting the ammonia injection rate via the MFC. The PLC will also provide safety shutdown interlocks for the hot gas fan and the ammonia injection system.

All slipstream operating parameters noted above will be logged, as well as data and alarm outputs from the Cemtek CEMS system and the Unisearch TDL ammonia analyzer. The DAQ system will be set-up to log 5-minute averages of all relevant data points on a 24-hour basis, with a single daily datalogger file created for each day of operation. The PLC/DAQ system will include remote access via a cellular modem link, to allow remote monitoring and control of the system. The PLC/DAQ system will also include an on-board FTP server to allow downloading of the daily datalogger files via the cellular modem link.

3.2 Gas Analysis Instrumentation

A complete CEMS package in a climate controlled enclosure will be ordered from a third-party vendor with extensive CEMS experience (CEMTEK) to provide the best possible reliability and functionality. The CEMS package will include simultaneous inlet (upstream of the catalyst bed) and outlet (downstream) measurements. Both the inlet and outlet streams will have separate NO_x , SO_2 , and O_2 analyzers. The CEMS will use Teledyne T200H analyzers for NO_x and O_2 and Teledyne T100H analyzers to measure SO_2 . The system will include all necessary flue gas handling and conditioning systems required for making accurate and repeatable measurements. An onboard PLC will handle daily auto calibration sequences, processes, and alarms. Figures 3-1 and 3-2 provide photographs of a typical CEMS enclosure and instrumentation rack (respectively) provided by CEMTEK.

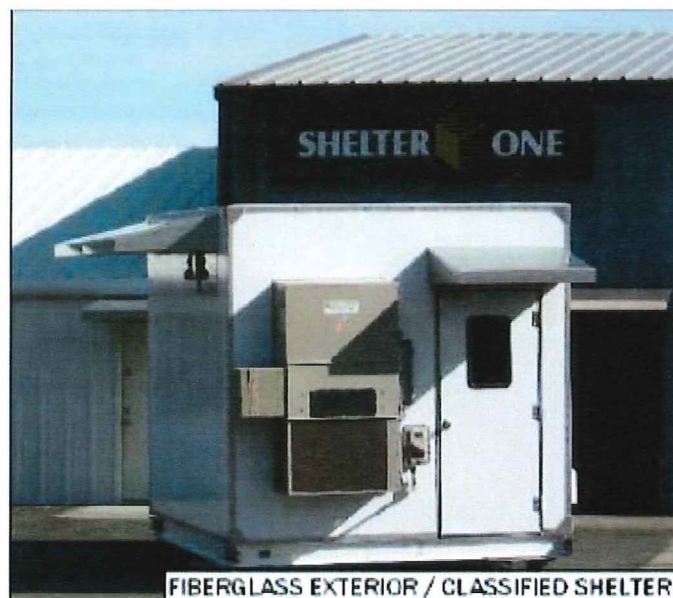


Figure 3-1. Example CEMS Enclosure

Additional space in the CEMS enclosure will be used to house the FERCo DAQ and PLC system as well as the NH_3 analyzer system. Data outputs and alarms from the onboard CEMS PLC will serve as inputs to the FERCo DAQ/PLC system that will control the test rig.



Figure 3-2. Example CEMS Instrument Rack

NH_3 will be measured at the inlet to the catalyst and at the exit. The measurements will be made using a two-channel Unisearch Tuneable Infrared Laser Instrument. This will be an *in situ* measurement in the ducts leading to, and from, the pilot SCR reactor. FERCo has extensive experience with this TDL technology and with the Unisearch instrument in particular. FERCo uses one of these instruments as part of our laboratory bench reactor where we test SCR catalyst to track activity. The Unisearch TDL analyzer is a fiber optic-coupled unit. The analyzer with the laser will be located in the CEMS enclosure. A fiber optic cable will transport the laser beam to the optics on the duct. The detector signal will be returned to the analyzer via a coax cable, see Figure 3-3.

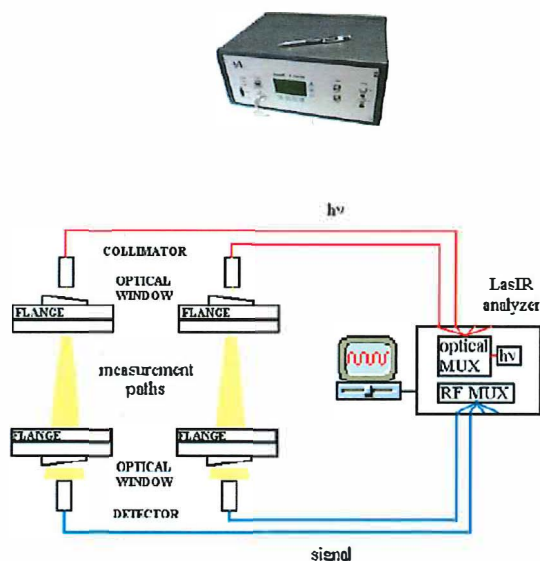


Figure 3-3. Unisearch Tuneable Infrared Laser Instrument

Optical paths for the laser will be incorporated at the inlet and outlet ducts. At the inlet, a normal 1m path will be created. Figure 3-4 shows a similar arrangement we use in our laboratory.

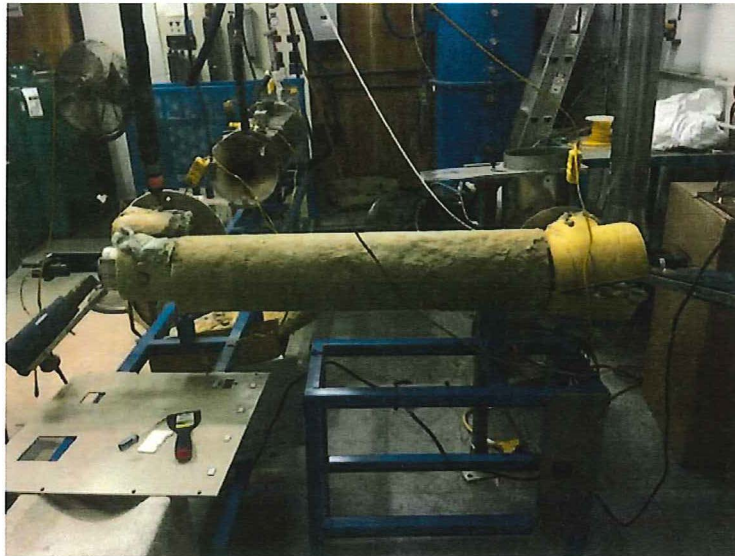


Figure 3-4. Single-path Laboratory Arrangement for NH_3

At the exit, a shorter path length will be used in conjunction with a Herriot cell optics. These are multipath optics that will provide an effective path length of 9m. Figure 3-5 shows the Herriot cell concept. FERCo is currently using this concept to measure ethane at a gasoline depot.

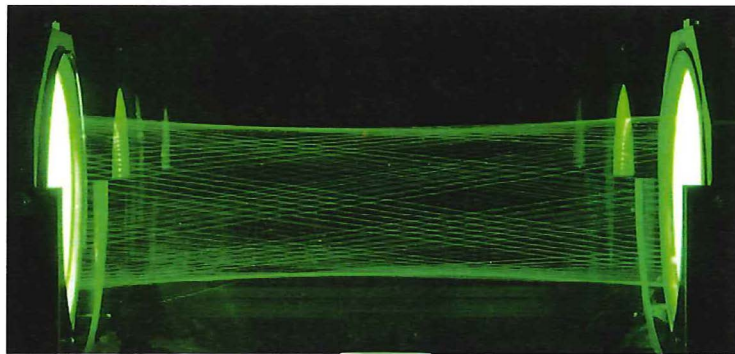


Figure 3-5. Herriot Cell Multi-Pass Visualization with Visible Light

The data signals and alarms from the Unisearch TDL- NH_3 analyzer will be input to the PLC/DAQ system.

3.3 Dioxin/Furan Measurements

Dioxin and furan measurements will be made by a qualified stack testing contractor chosen by Essroc. Measurements will be completed upstream and downstream of the catalyst bed at the same locations that the CEMS measurements will be made. A third sample location ahead of the flue gas reheat section will be required to determine the effect of the reheat process on

dioxin and furan concentrations. Currently, the dioxin/furan sample ports will be specified as 2-inch NPT.

4

SYSTEM OPERATION

After system commissioning and start-up, the system must be operated for a length of time that ensures “120 days of valid data”. For the purposes of this work, “valid data” will be data collected while all flow rates were maintained at the appropriate set points, including reagent flows and flue gas flows, temperatures are maintained within acceptable ranges, kiln operation is acceptable, and daily calibrations are completed.

The slip stream system will be designed to be controlled almost completely automatically by a PLC so as to require very little attention from Essroc personnel. The PLC will control and maintain the flue gas flow rate through the system, the flue gas reheat process, the heating jackets, and the NH_3 injection rate. The PLC/DAQ system will use the inlet and outlet NO_x concentrations to determine the NO_x removal. The NH_3 injection rate will then be adjusted to achieve a target NO_x removal.

To avoid the possibility of moisture and particulate deposition during kiln or pilot start-up, the pilot unit will include preheat capability using heated air prior to the introduction of kiln flue gas. Likewise, during shut down a hot air purge will also be used to clear flue gas from the pilot unit.

Essroc personnel will be required to complete a daily visual inspection as well as perform sootblowing of the two catalyst beds. Primary monitoring and operation of the system will be the responsibility of FERCo personnel. This will be accomplished remotely as well as with on-site visits. After the commissioning and the initial startup, FERCo personnel will make site visits every two weeks for the first 8 weeks of the test program. These site visits will provide an opportunity for an in depth inspection of the equipment and to perform any maintenance required. After the first 8 week period, the frequency of site visits will be reduced to a nominal 4-week interval for the remainder of the 120-day test program. In addition to the site visits described above, FERCo personnel will monitor the operation of the system remotely via a cellular modem link to the PLC/DAQ system. This remote monitoring will take place on a daily, or almost daily, basis to ensure that the “120 days of valid data” requirements are met.

5

PROJECT SCHEDULE

Table 5-1 provides a schedule for the proposed project, showing nominal dates for various tasks and milestones. Please note the proposed schedule is entirely dependent on U.S. EPA's timely approval of this Design Report. Kiln 2 at the Logansport facility is scheduled to have a mid-kiln SNCR NO_x removal system installed and operational by March 31, 2017. Therefore, it is important the 120-day test period be complete by this date.

Table 5-1. Proposed Project Schedule

Date	Task/Milestone
1/31/2016	U.S. EPA approval of Design Report
2/1/2016	Essroc issues FERCo Purchase Order to proceed with design
2/14/2016	FERCo site visit to Logansport facility
3/14/2016	Completed FERCo design and cost proposal submitted to Essroc
6/14/2016	Fabrication complete at FERCo
7/14/2016	Shakedown testing complete at FERCo
8/1/2016	Ship equipment to Logansport facility
8/7/2016	Start equipment installation and set-up at Logansport facility
9/1/2016	Begin on-site start-up and shakedown testing
9/15/2016	Start 120-day test
1/15/2017	End 120-day test
3/15/2017	Submit report

For planning purposes it has been assumed U.S. EPA approval will be received by January 31, 2016. It has also been assumed Essroc will issue FERCo a purchase order to proceed with system design and specification immediately upon receiving approval from U.S. EPA. Once the purchase order has been received, FERCo will schedule a site visit to the Logansport facility to meet with plant personnel for the purpose of collecting data and information to enable us to provide a proper design and cost proposal. This proposal will be submitted to Essroc approximately one month after the site visit.

Fabrication of the system will require approximately three months from the time the detailed design and cost proposal is approved by Essroc. Please note, the critical path item in the fabrication timeline is the CEMS equipment and enclosure. The preliminary quote received from CEMTEK for this equipment stated a 20 to 24 week delivery time. It will be necessary to place the order for the CEMS equipment and enclosure immediately upon Essroc's issuance of the purchase order to FERCo (nominally February 1, 2016 as indicated in Table 5-1) in order to

have the CEMS equipment at the FERCo facility by the time the rest of the equipment fabrication is complete in mid-June.

System shakedown testing at the FERCo facility in California is anticipated to require one month. The system will be then be packaged for shipping to the Logansport site. A dedicated flatbed truck will be required for shipping due to the anticipated size of the pilot test skid and the CEMS enclosure. Installation will begin in early August, with a 2-week on-site start-up and shakedown process starting on approximately September 1st. The 120-day test program is anticipated to begin in mid-September and then conclude in mid-January, 2017.

The final task will be consolidating the data and preparing a final report. The report will evaluate the following items with respect to the operation of the pilot SCR system over the test program:

- a. Emission reductions of NO_x
- b. Observed deactivation of poisoning of the SCR catalyst
- c. Ammonia usage
- d. Adverse environmental consequences related to the use of SCR
- e. Anticipated and observed lifetime of the catalyst
- f. Anticipated or observed space velocity of the system

A

FERCo SCR Pilot Plant Experience

FERCo is an engineering service company founded in 1984 specializing in combustion and NO_x control. This includes an extensive amount of experience in SCR technology. This SCR experience covers the range from fundamental studies, system design, process modeling, pilot scale testing, and full-scale testing. This Appendix will outline FERCo's pilot scale experience. This pilot scale experience started in about 1980 while some FERCo staff were at a prior employer and continues in 2015.

(1980-1986) EPRI: Public Service of Colorado, Arapahoe Station, Denver, CO

FERCo staff were responsible for the operation and testing of the first major utility coal-based pilot plant. This was a 5,000 scfm SCR reactor that included a regenerative air preheater. This pilot study, which spanned two years, dealt with both SCR performance and ammonium bisulfate air preheater issues.

(1991-1993) EPRI: Three Small SCR Pilots

FERCo designed three small SCR pilot units for EPRI. FERCo also fabricated the instrumentation to monitor these pilot units. These pilot units consisted of two parallel reactors, each 1 ft x 1 ft in cross section. Two were set up at different coal-fired utility power stations and the third at an oil-fired utility power plant. In addition to designing the units, FERCo operated the pilot unit installed on the oil-fired unit in Oswego, NY.

(1996-1998) PG&E/EPRI: Morro Bay, California (Figures A-1, A-2)

This was a 5,000 scfm SCR/air preheater pilot plant installed at PG&E's Morro Bay oil- and gas-fired power station. FERCo participated in the overall design of this system and designed and fabricated the gas analysis instrumentation for the unit. In addition, FERCo was responsible for operating the system for a nominal 1.5 year period. This pilot study went beyond just catalyst performance and included:

- AIG ammonia mixing
- Air preheater ammonium bisulfate (ABS) issues
- Particulate issues associated with ABS
- Catalytic air preheater baskets
- Use of urea as the SCR reagent

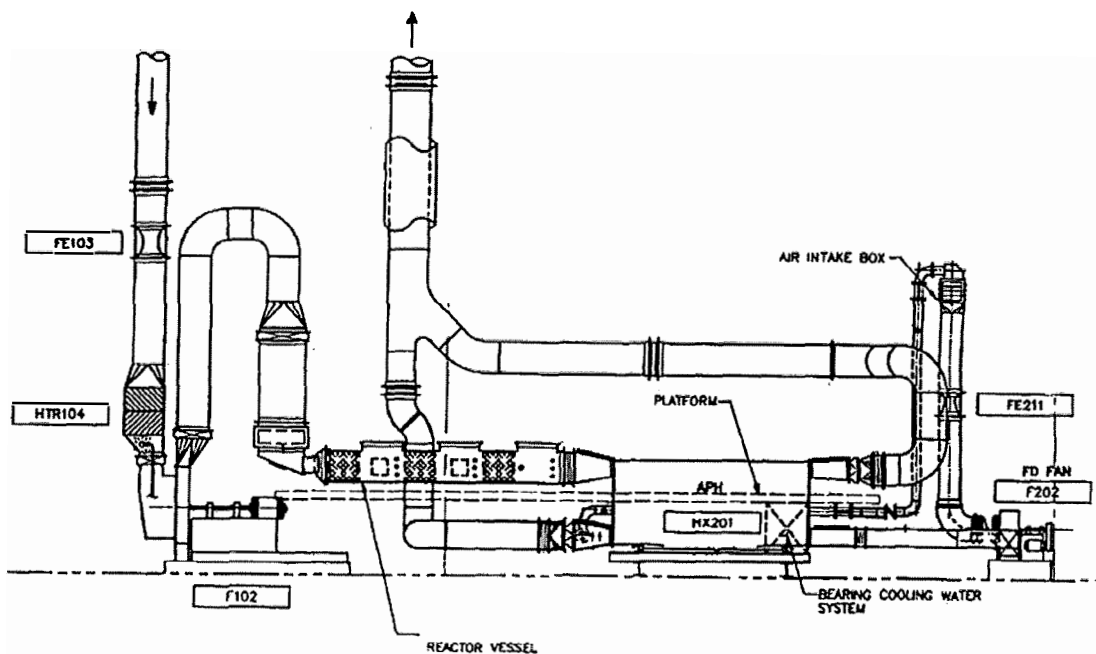


Figure A-1. Morro Bay Pilot Plant

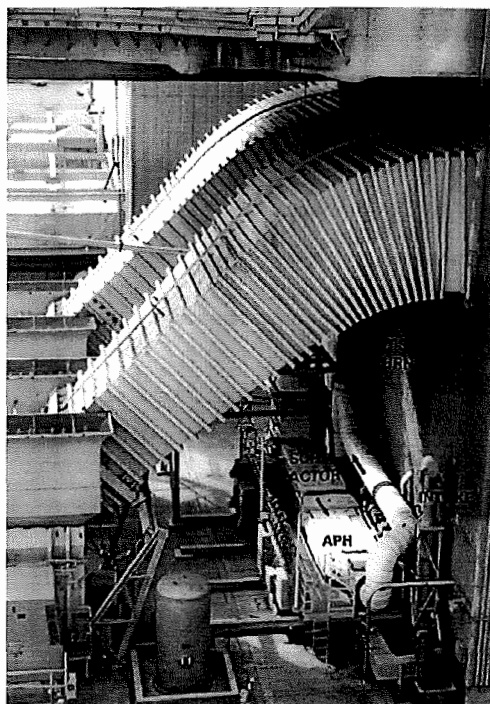


Figure A-2. Morro Bay SCR Pilot Plant

(1999-2011) FERCo *In situ* Mini SCR Systems (Figure A-3)

With the deployment of SCR systems to the coal-fired utility fleet beginning in about 2000, there was concern about catalyst deactivation rates for the various coal types used in the U.S. FERCo designed an *in situ* system (varying from 2" x 2" up to 6" x 6" (10 scfm to 100 scfm) that allowed a catalyst sample to be installed within a flue gas duct. The design allowed the catalyst sample to be exposed to flue gas at actual temperatures with flows controlled to typical SCR reactor velocities. FERCo built nine of these systems with the various test programs being 4 months to 18 months. The test programs covered the following:

- PRB coal
- High arsenic Eastern coal
- Biomass
- Texas Lignite
- Petroleum coke

Mini-Reactor (1 of 2)



Control Cabinet



Figure A-3. FERCo *In situ* Mini SCR System

(2007) Mobile SCR Reactor for Mitsubishi Heavy Industries

FERCo was contracted to design and build a portable slip stream reactor (4" x 4", 40 scfm) that could be easily moved from power plant to power plant. The goal was for MHI to assess new catalyst formulations to promote mercury oxidation.

(2007-2009) EPRI/Luminant Pilots: Sandow Power Station

FERCo participated in the design of this pilot unit, fabricated the instrumentation for the pilot, and operated the pilot system for 2 years. This was a nominal 1500 scfm slip stream reactor (24" x 24" cross section) located at the Sandown Power Station firing Texas Lignite.

(2014-2015) EPRI Portable Catalyst Test Facility (Figures A-4, A-5)

Recently FERCo designed and built two identical slipstream SCR reactors for EPRI. These are each 6" x 6" (100 scfm). Both systems were recently used at Detroit Edison's Monroe Station (Sept/Oct 2015) for a side-by-side assessment of catalyst activity, SO₂/SO₃ oxidation, and mercury oxidation for both new and regenerated catalyst. FERCo is also responsible for installation and operation of these two units when they are used at a particular power plant. The proposed ESROC SCR pilot unit will be similar to these units.

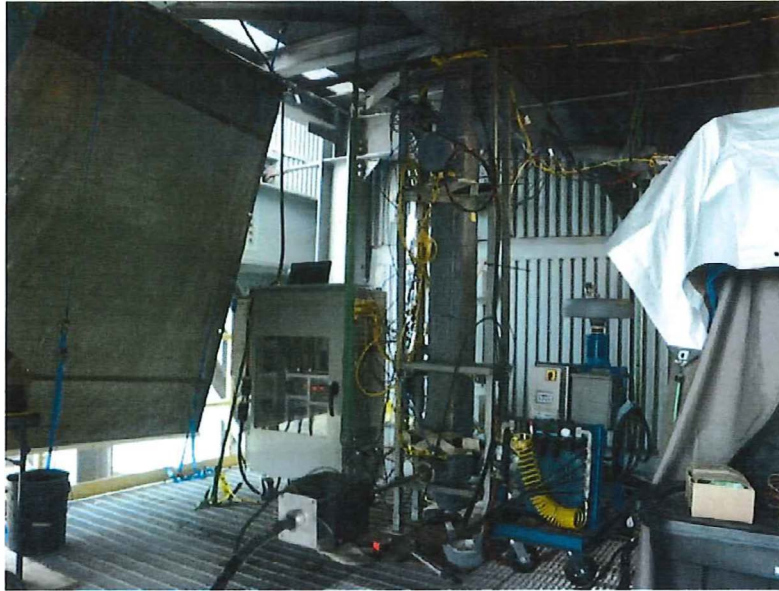


Figure A-4. EPRI Portable Catalyst Test Facility

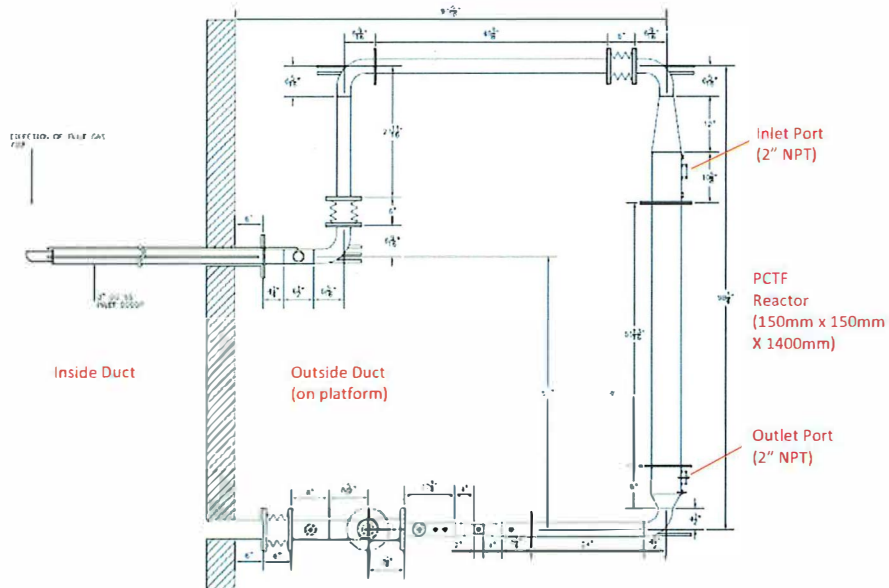


Figure A-5. EPRI Portable Catalyst Test Facility (PCTF)